

OAK-TREE

One-of-a-Kind Traffic Research and Education Experiment

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The creation and progress of OAK-TREE (One-of-a-Kind Traffic Research and Education Experiment) are chronicled. OAK-TREE is a traffic educational laboratory experiment that was developed and conducted at the University of California at Irvine (UCI) during the spring quarter of 1996. This project involved a cooperative effort between the academic community and public-sector transportation operating agencies in developing a comprehensive field and laboratory educational experience for undergraduate students in transportation engineering. The agencies involved in this effort were the Department of Civil and Environmental Engineering at the University of California at Irvine, the Advanced Traffic Surveillance and Control Center of the city of Los Angeles, the Transportation Management Center of the city of Anaheim, and the Irvine Traffic Research and Control Center of the city of Irvine. These agencies were instrumental in creating an innovative laboratory experience for academic training in the use of state-of-the-practice resources and methods for traffic engineering. The results were the development of a state-of-the-art traffic-control educational laboratory at UCI and the genesis of a unique traffic-control course that fulfilled the requirements of both fundamental academic education and rigorous professional training.

In an article that discusses undergraduate transportation education (1), Lipinski and Wilson indicate that finding qualified entry-level transportation engineers is a major concern for employers of transportation professionals. They also state that employers indicate that entry-level engineers lack significant exposure to transportation engineering methodologies. To remedy this problem, practitioners and educators have been working together to develop a more effective curriculum in transportation engineering.

The idea of a partnership between government or industry and educational institutions has been discussed increasingly in recent years, and such partnership arrangements have been implemented in different forms. It is easy to appreciate that such an arrangement can be advantageous to both sectors. On the one hand it provides students with the opportunity to gain real-world experience, and on the other it provides industry with the opportunity to evaluate prospective employees.

One way by which this is achieved is through feedback from professionals on making changes in the engineering curricula. Another way is through cooperative education programs in which a student is offered a professional work opportunity while he or she

is obtaining academic credits. The results of a questionnaire administered to academic institutions and industry (2) found that the experiences of academic institutions and industry involved in such programs have been mutually beneficial and productive. Along these lines, OAK-TREE (One-of-a-Kind Traffic Research and Education Experiment) was developed at the University of California at Irvine (UCI) to promote an industry-academia partnership. The concept was developed as an upper-division course in the transportation engineering area of the civil engineering B.S. program. The specific course, CE129—Traffic Control Systems Laboratory, consisted of a traditional lecture-discussion format coupled with an intense laboratory experience that was both managed and developed by practicing traffic engineers and incorporated field experience with their traffic management systems. Approximately 50 students were enrolled in the course.

The course provided an overview of current traffic-control system technology, with emphasis on the proper application of this technology toward improving traffic flow, reducing congestion, and improving the quality of life in urban areas. Topics covered included the following:

- Control system functions: data gathering, decision making, execution, verification, and evaluation.
- Hardware: detectors, local controllers, system masters, communications, and display.
- Control variables: vehicle presence, flow rate, occupancy and density, speed, headway, and queue length.
- Traffic signal timing parameters: phasing options, variable-sequence phasing, and offsets.
- Actuated control: minimum green, passage time interval, and maximum interval.
- Arterial street control: timing plan elements, arterial progression, and time-space diagrams.
- PASSER II-90: analysis, evaluation, and implementation.
- Network control: TRANSYT-7F and QUICK7F.
- TRANSYT-7F coding: data preparation and analysis.
- Network optimization: evaluation and implementation.

Table 1 presents the laboratory schedule.

One of the advantages of OAK-TREE is that it provides broad exposure to the state of the practice to students in the transportation engineering program, rather than just to the few students who are selected for corporate internships.

The changing nature of the field of transportation, accelerated by the advent of intelligent transportation systems (ITS), requires students in transportation to acquire more skills in newer technologies related to electrical engineering. This was addressed through OAK-TREE by providing an opportunity to learn about ITS components

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TABLE 1 Traffic Control-Systems Laboratory Schedule

Week	Lab Topics	Lab Exercise	Lab Assignment
1	The Traffic Signal Environment Reading a signal plan Hardware basics Basic input Basic output Basic communications	Looking inside the cabinet. What to look for when input goes wrong. What to look for when output goes wrong.	Identify elements of a signal plan. Locate deficiencies in the signal plan. Identify connections from cabinet wiring diagram.
2	Traffic Signal Design: Input Loop operation Loop design Safety issues	Given a wiring cabinet with locations of detectors, identify where loops are connected. Identify problems in detection wiring.	Design loop placement for various approaches. Design for loop gap operation.
3	Communications Design Communications basics Basic fiber optic design Project management Systems perspective	Looking at the signal hardware equipment. PV equipment. How to locate signal hardware problems.	Design a network intertie for a group of interconnected signals. Cost-benefit analysis. Construction of a time-space diagram.
4	Signal Timing Basics Data collection & inventories Signal timing Interpretation of timing charts	Define signal timing problem.	Field trip to L.A. to collect counts, speeds, check striping for "Before Study."
5	Signal Timing Analysis Timing problems Use of HCS	HCS coding for "Before Study" and problems	Complete data reduction (inventories), Complete HCS analysis of "Before Study."
6	Arterial Signal Progression PASSER II software	PASSER II coding.	PASSER II analysis.
7	Network Signal Coordination TRANSYT-7F software	TRANSYT-7F coding using QUICK-7F software	TRANSYT-7F analysis.
8	Network Signal Coordination (Cont.) TRANSYT-7F calibration Preparation of timing charts Type 170 controller practice	Field trip to L.A. - timing installation and "After Study."	TRANSYT-7F calibration and optimization.
9	Event Management Modern TMC operations	Field trip to Anaheim TMC - Apply CCTV, CMS, HAR & centralized signal control in management of CA Angels traffic	Preparation of report documenting procedures for event management
10	Network Signal Coordination (Cont.) Fine tuning Before-after study comparison	Finalize Type 170 timing charts.	Preparation of Final Report

and electrical engineering basics without requiring the transportation student to take on additional electrical engineering classes. Under this arrangement the teaching of sound fundamentals in transportation is not sacrificed at the expense of introducing newer engineering skills.

Specifically, the newer engineering skills that OAK-TREE emphasizes are advanced skills in quantitative analysis, computers, and communications. These skills were mentioned by Pignataro (2) as being vital to the curriculum of a transportation education program and are taught through OAK-TREE at an advanced traffic-control laboratory that was built to support this educational activity. The laboratory houses entire traffic-engineering systems from detectors to controllers to different types of signals. In addition, the partnership with city agencies allows the design of assignments

around real-life networks and intersections. These same partners also provide computer training in the advanced software used in the cities' day-to-day traffic-control operations. The students also are required to practice their communication skills by submitting at the end of the course an analysis report much like one that would be submitted by consultants in the industry.

TRAFFIC-CONTROL LABORATORY

To educate students on current traffic-control practices, a laboratory is needed in which students can experiment with field equipment before they make field adjustments. With the assistance of the cities of Irvine and Los Angeles and private companies, UCI

was able to acquire state-of-the-art equipment for use in the laboratory.

Figure 1 shows Western Signal WP-100 controller cabinet along with a programmed visibility head and a pedestrian head, housed in the traffic-control laboratory. In addition to the NEMA cabinet, there are Type 332 and Type 337 cabinets. Two types of detector, infrared and inductive loop, are connected to the various cabinets. These field instruments allow the students direct access to field components that typically are either inaccessible because of mounting location or too critical to be manipulated.

Tools were acquired so that students in the laboratory can troubleshoot and build test equipment. These included basic tools such as a digital multimeter and a soldering station and controller-specific tools such as wire crimpers and pin insertion and removal tools. Test apparatuses such as PC-to-Type-170 controller download cables were built. Type 170 testers and Type-170-to-parallel-port interfaces also can be built for educational purposes.

The OAK-TREE laboratory contains the following equipment:

- Loaded Western Signal WP-100 traffic controller cabinet with multisonic NEMA controller;
- Eight-foot programmed visibility signal head with pedestrian head;
- Loaded 332 traffic controller cabinet with 170 controller;
- Loaded 337 traffic controller cabinet with 170 controller;
- Econolite zone monitor, zone master, and ASC/2-2100 NEMA controller system;
- Model 170 controller, stand-alone;
- Two multisonic nine eleven controllers;
- MPH S80 speed radar;
- Two Jamar traffic counter boards;
- One infrared presence detector and one infrared pulse detector;
- Signal control Model 1100, 170 tester;



FIGURE 1 OAK-TREE traffic-control laboratory.

- Eleven Model 200 switch packs;
- Seven Model 222 loop detector sensor units;
- Four Model 224 loop detector sensor units;
- Five Model 252 AC isolators;
- Industrial computer system lablog data acquisition system;
- Amerlink loop cables;
- Sportline stopwatches;
- Weller soldering system;
- Amp "M" Series insertion and extraction and crimping tools (C1 connector);
- 170-to-PC download cable;
- Internet connection to freeway traffic information; and
- Tektronix multimeter.

In addition, the civil engineering undergraduate computer laboratory was used to complement other equipment resources. This computer laboratory had more than 20 personal computers and several printers. The laboratory was an adequate facility in which to teach transportation software. However, it lacked a monitor projector, which is desirable hardware for this kind of instruction. A monitor projector would allow the instructor to show the computer display simultaneously to the whole class. This setup will be pursued in the near future.

COURSE MATERIAL

To provide real-life traffic engineering exercises, guest instructors from three cities formulated different parts of the course. The combined efforts produced a broad and complete picture of the state of the practice in traffic engineering. The instructors were a UCI professor, a laboratory coordinator, and more than 10 outside lecturers and teaching assistants. Each instructor taught his field of expertise within traffic engineering. City of Irvine staff gave the general orientation on traffic-signal environment and electrical engineering basics; city of Los Angeles staff focused on signal timing and coordination, and city of Anaheim staff discussed the intricacies of special-events management. These courses were intended to sharpen the quantitative analysis and communications skills of students and introduce advanced computer techniques.

Instruction Provided by Irvine Transportation Engineering Staff

City of Irvine transportation engineering staff initiated the traffic laboratory course by orienting the students to the traffic-signal environment. Because the laboratory housed examples of field equipment, students received a detailed explanation of field-hardware basics. These included poles, mast arms, heads, pedestrian heads and pushbuttons, conduits, pullboxes, loops, conductors, types of cabinets, and controllers. The city signal, lighting, and electrical-systems standards were explained and the students were assigned to develop as-built plans of existing intersections using the city's signal, lighting, and electrical-systems symbols.

Emphasis was placed on understanding the controller cabinets and the traffic controllers because these were the critical components that would be used in a signal-timing analysis that the students later would perform in Los Angeles. Because all the transportation students in the course were civil engineering majors, the city of

Irvine traffic engineer presented a primer on electrical engineering basics related to signal operations. The functionality of such electrical components as power supply, detectors, flasher, and load switches was described, as was that of cabinet wiring. As a result, students had the opportunity to troubleshoot cabinet wiring problems. Since detectors are the eyes of any traffic-management and control system, one week was devoted to covering loops and other, more advanced forms of detection. Experiments were conducted with the inhouse loops by using metal objects to disturb the loop inductance. Some advanced detectors also were covered, including infrared detectors and video image detection.

Communications design issues also were touched upon by the city of Irvine staff. Types of physical media were presented including twisted pair, microwave, coaxial, and fiber optic. The advantages and disadvantages of each type of material were compared according to the bandwidth, cost, and operations theory.

The city of Irvine portion of the course concluded with a discussion of issues related to signal warrants. Following an overview of published regulations, the more complex real-life occurrences were highlighted. An aspect of particular concern was the day-to-day challenge for the traffic engineer to interact with citizens and citizen groups. It was emphasized that traffic engineers must be systematic and careful in documenting their work, because of the possibility of legal actions against the city. Points also were presented on the role of the traffic engineer as a part of the government entity and on how departments interact in a city agency.

Instruction Provided by Los Angeles Transportation Engineering Staff

The city of Los Angeles portion of the course required the students to make a comprehensive study of a closed network in Los Angeles that comprised 21 intersections. The purpose of this project was for the students to retune an entire signal network.

Figure 2 is a map of the study network, located near the University of Southern California. The minor intersections in the network were not considered. This network was a good candidate for educational study because it contained diverse signal configurations including T-intersections, offset signals that required signal-timing overlap, and freeway on- and off-ramp metering signals. Because of time constraints, the project focus was on a closed-loop network. However, students were required to investigate other issues related to the network, such as the interaction effects of the network with surrounding traffic and cross traffic.

The comprehensive study covered the following aspects:

- Data collection and inventory,
- Current timing evaluations,
- Individual timing analysis,
- Progression study,
- Networkwide coordination,
- Field calibration,
- Timing optimization,
- Timing installation, and
- Performance evaluations.

The class was split into three groups to study the morning, mid-day, and evening peak periods. Within each group, each student was given two intersections to analyze. The student was then in charge

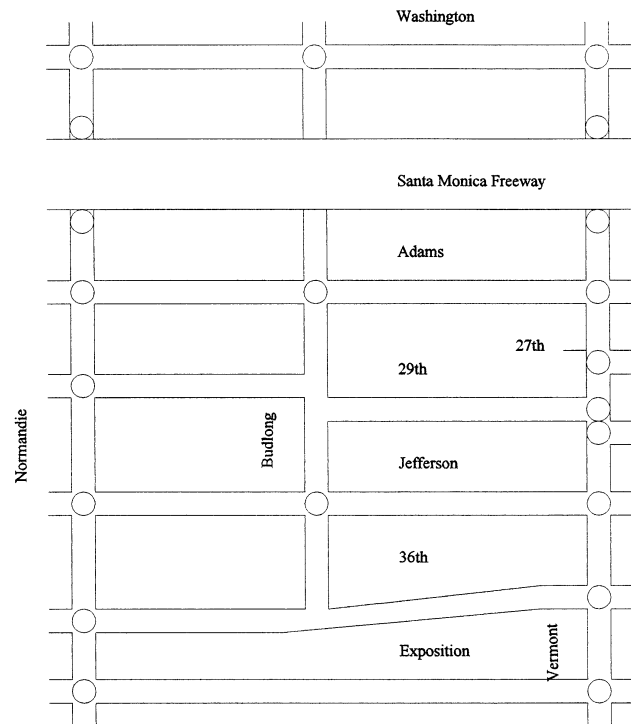


FIGURE 2 Study area in the city of Los Angeles.

of data collection and signal timing for those intersections. Traffic-count data were collected for the respective time periods for each of the 21 intersections. Many floating car runs also were performed to obtain stop and delay information for the network.

The intersections were analyzed for striping, cycle lengths, vehicle clearance intervals, pedestrian timing, and splits. Highway Capacity Software was used to determine the current level of service as well as that expected with alternative timing plans. The students were asked to consider such issues as the following:

1. Operations versus planning method,
2. Effects of left-turn phasing,
3. Benefits of left-turn pockets,
4. Pedestrian capacity,
5. Effects of long cycle length,
6. Different phasing alternatives,
7. Differences in arrival types, and
8. Nearside versus farside bus stops.

When the students were familiar with details of individual intersections, they were required to tackle the problem of progression. Progression Analysis and Signal System Evaluation (PASSER II) was used to improve progression in corridors of the network. In addition, time-space diagrams were emphasized using TS-PLOT, a software tool developed by the Los Angeles Department of Transportation. TS-PLOT allowed the students to graphically change the timing splits and phasing and to see the resulting passbands.

The last part of the network study involved the use of the traffic-simulation study tool (TRANSYT 7-F) for simulation and optimization. Each time-period group of students was required to simulate and calibrate models for the entire network. New optimized signal timings were developed for the 21 intersections. The TRANSYT 7-F

output was converted into Type 170 controller timing charts. Each student was then trained in the general operation of the Type 170 controller. Finally, with timing chart in hand, the students implemented the new timing in the field. Each group was given the opportunity to fine-tune the splits and offsets once they were acquainted with site conditions.

To conclude the study, students were required to repeat the floating car runs and to contrast the before and after conditions of the network. Thus, each student was able to experience the process and appreciate the difficulties of state-of-the-art network signal timing.

Instruction Provided by Anaheim Transportation Engineering Staff

The city of Anaheim is one of the largest cities in Orange County and incorporates a number of special-events capabilities in its management of traffic. In addition to two major amusement parks, Disneyland and Knott's Berry Farm, Anaheim also contains major sports complexes such as Anaheim Stadium and Arrowhead Pond, which house major-league professional teams, and a major convention center (Figure 3).

Faced with the task of coordinating traffic for such major sources and sinks, the Anaheim traffic-management center (TMC) is equipped with the latest advancements in advanced traffic management systems. These could be used as a valuable learning experience for students on the topic of special-events handling.

In this component of the course, students had an opportunity to familiarize themselves with the ITS components in the TMC. They received hands-on experience in guiding the closed-circuit television cameras and in querying the graphical traffic-information system for current traffic conditions and signal plans. They were able to learn about the formulation of changeable message signs and the recording of the daily highway-advisory radio announcements.

The class project for this part of the course involved participation in handling ingress and egress of motorists at Anaheim Stadium and Arrowhead Pond for two major sports events. The students assisted in the incremental changing in signal-timing strategies as traffic increased near the start of the events, and they gained a sense of appreciation for the coordination between the

TMC and the field police officers, parking attendants, and floating patrol cars. The event staffs offered a different perspective on the current traffic condition from their vantage points.

FEEDBACK FROM COURSE PARTICIPANTS

At the end of the quarter, a survey was conducted of all the student participants in the course. A wide range of questions was asked to get a complete picture of the student response. Students were asked general questions on course structure and organization as well as questions directed specifically toward the effectiveness of a class designed through professional and academic partnership. Three questions in particular were significant in verifying that the students considered the experience to be valuable and encouraged the continuation of such efforts. Figure 4 illustrates that 69 percent of the students either strongly agreed or agreed that the integration of material among three cities provided them with a broad picture of traffic control and was effective in teaching them about a wide range of practical traffic-engineering skills. Figure 5 illustrates that 86 percent of the students strongly agreed or agreed with continuation of the team concept of professionals and academics. Figure 6 illustrates that 89 percent either strongly agreed or agreed with the statement that field experience complemented theory with real-world engineering practice; this response indicates the importance of hands-on experience in field locations in addition to instruction in a controlled laboratory environment.

Despite the overwhelmingly positive responses from the students, some difficulties surfaced. Because of the popularity of the course, the class was too large for an upper-division laboratory. The enrollment of almost 50 people was problematic at times during the quarter. The demands from such a large class stretched both human and equipment resources. For example, it was difficult to demonstrate and perform exercises based on the controller cabinet because the space in front of the cabinet door was limited. Although the class was divided into three groups for the final laboratory project, each

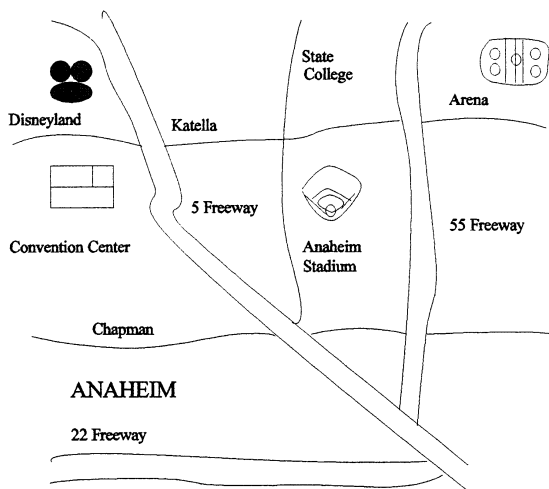


FIGURE 3 City of Anaheim special-events complexes.

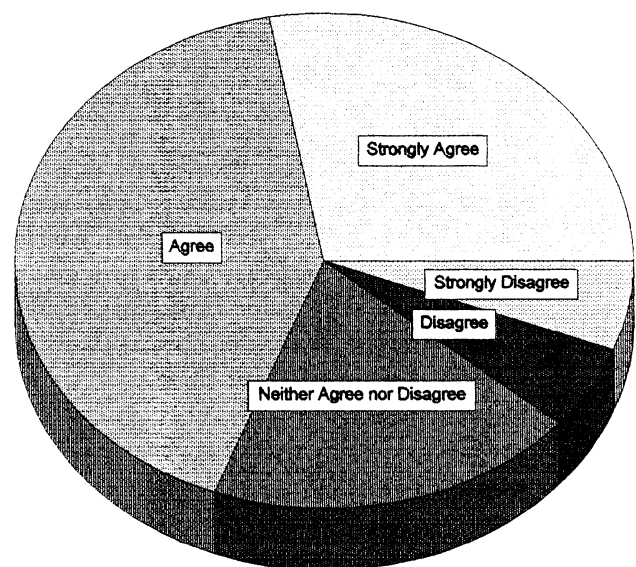


FIGURE 4 Response to survey question: Did integration of material among three cities provide broad picture and was it effective?

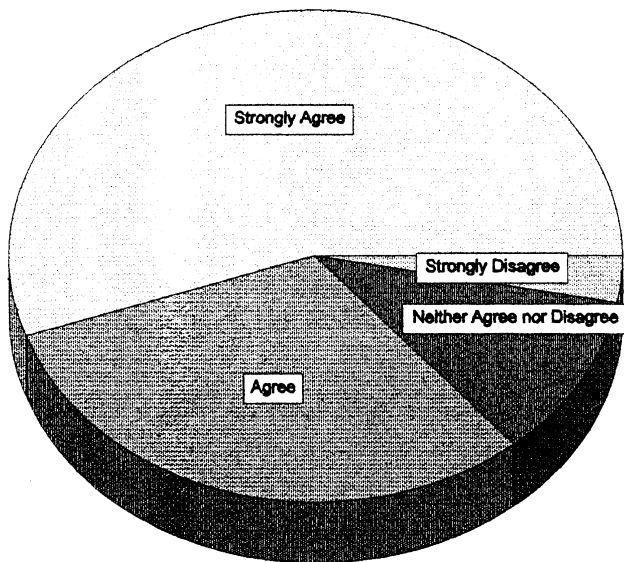


FIGURE 5 Response to survey question: Should the team concept of professionals and professors be tried more often?

group was too large to allow a well-balanced distribution of work among all the members. The lessons learned from such problems led to adjustments that will be discussed in the next section.

FUTURE DIRECTIONS

OAK-TREE supports improvement of communications among the academic community, the private and public sectors, and governmental agencies through its innovative approach to the development of a traffic-control laboratory and course that exploits interaction between practitioners and academics. As academic programs increasingly try to accommodate industry's demands for a better-prepared engineering graduate, OAK-TREE and other efforts such as co-ops seek to meet such demands. The glimpse of the traffic-engineering discipline that students get from the OAK-TREE experience allows them to sharpen their analysis skills in the context of real-world problems.

From student responses to OAK-TREE it can be concluded that the course was successful in its efforts to educate students in the fundamentals, day-to-day practice, and state-of-the-art advances in traffic engineering. Almost all of the students appreciated the opportunity to use a laboratory that captured so much of the real-life traffic engineering experience.

Thus, it is the authors' view that such efforts, especially in laboratory-type classes, should be tried more often in civil engineering programs. A well-organized effort and effective cooperation between industry and academia can produce benefits for all the parties involved. In addition to the education that the students obtain, indus-

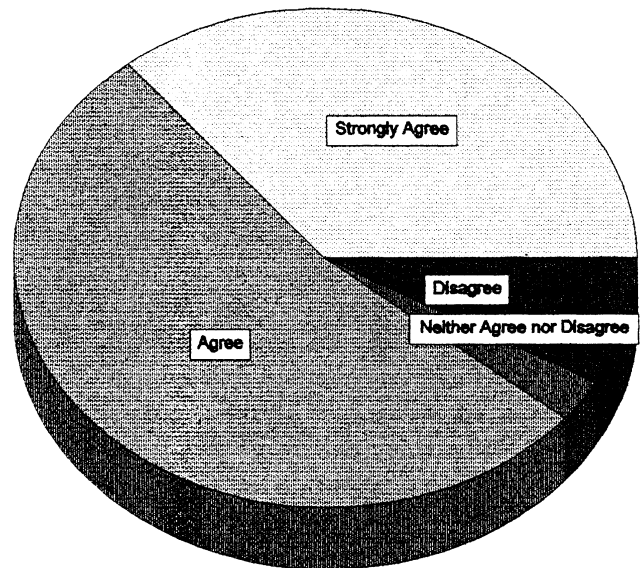


FIGURE 6 Response to survey question: Did field trips complement theory with real-world engineering practice?

try benefits by helping to shape the new crop of graduates and evaluating these future employees. The academic institutions benefit by offering better training for their students.

To remedy the problems associated with class size, it was decided that the enrollment should be curbed. This will diminish the opportunity for some to participate in this laboratory experience; however, the experience will be more meaningful for those who do participate. The network for the final project will be reduced so the group size can be smaller, resulting in a more balanced workload among the members of each group.

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